AMS-458

AIR DOOR FOR COLD STORAGE HOUSES

(An Interim Report)

Transportation and Facilities Research Division
Agricultural Marketing Service
United States Department of Agriculture

PREFACE

This report is based on research done under a long-range project at the Wenatchee, Wash., field office of the Transportation and Facilities Research Division, Agricultural Marketing Service, to improve the operation and design of cold storage houses for apples and other tree fruits. Improved efficiency in marketing farm products is the objective of a broad program of research by the Agricultural Marketing Service, and this study is a part of the program.

The results reported here are preliminary, and subsequent reports will be released as further work warrants. Because of the increasing interest in the air door by storage and packinghouse operators, it was decided to release the preliminary results prior to completion of the entire project. It is expected that a large number of air doors will be installed in new apple storages in the Pacific Northwest, or will replace existing types of secondary or inner doors, which are often damaged by handling equipment. This report includes guidance for the construction of an air door and an estimate of the cost for building it.

The drawing in this report is not complete in all details, or dimensions, as these will vary at each installation. However, the details are complete enough to be used as a guide in the construction of an air door. This research was carried on under the general supervision of Joseph F. Herrick, Jr., marketing research analyst, Handling and Facilities Research Branch, Transportation and Facilities Research Division.

The Skookum Packers Association, Inc., constructed the air door and assisted in this research.

CONTENTS

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AIR DOOR FOR COLD STORAGE HOUSES

by Glenn O. Patchen, mechanical engineer
Transportation and Facilities Research Division

SUMMARY

The air door discussed in this report involves the flow of air moving across the face of a door opening. This flow of air in effect seals the entrance and acts as an insulating curtain; it eliminates the need for swinging or sliding doors and provides an unobstructed entrance and exit.

Moving the air horizontally eliminates the necessity of having a pit and underground ducts.

Since the forklift truck operator has a clear view through the door at all times, accidents are reduced.

The maintenance cost on such a door is very low and consists mainly of servicing the motors periodically. The heavy, insulated door is left open during the operating hours, and the air current of the air door prevents dust and dirt from passing through the doorway.

BACKGROUND

Operators of cold storage rooms in the United States have shifted to the use of industrial forklift or clamp-type trucks for moving large lots of apples at one time. This equipment requires special doors to the storage plant. These doors must be opened speedily or left open in order not to slow down the handling operation.

Mechanical sliding or swinging doors limit the truck operator's vision and are normally slow in operation. This makes it necessary to slow down or stop the forklift trucks while the doors are opened. The doors are often damaged by the forklift trucks and repairs are costly. Oftentimes, the doors are left open during busy periods. Leaving the doors open causes an excessive loss of refrigeration and allows warm air to flow into the storage. The warm air puts an additional load on the refrigeration plant at a time when all the refrigeration capacity is needed for cooling the fruit going into storage.

The air door is not a new idea. Air doors have been used in department stores, cold storages, and other commercial buildings. They eliminate many of the conventional hazards and drawbacks by giving the operator of the forklift truck a clear opening with unobstructed vision, and they keep air exchange at a minimum.

The air door installed in this test effectively reduced the air exchange of the storage when the main door was left open. Hukill and Smith 1/ in their report on "Cold Storage for Apples and Pears" made the following statement

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1/ Hukill, W. V., and Smith, Edwin. "Cold Storage for Apples and Pears." U. S. Dept. Agr., Cir. No. 740, Feb. 1946.

about heat loss through open doors: "If it is assumed that a draft having a velocity of 200 feet per minute is leaving a cold room at 35°F. through the lower half of a doorway 4 feet wide and 7 feet high and an equal current of dry warm air at 65° is entering the upper half, an estimate of the entering heat can be made; 200 feet per minute is about 2¼ miles per hour and is not a very noticeable velocity. Under these conditions, however, 100,000 B.t.u. (British thermal units) per hour would enter through the open door. If the air were not very dry, the quantity would be even greater. It would keep an 8-ton machine busy just to remove this heat."

With the advent of forklift trucks, doors had to be made much larger. A door 8 feet wide by 11 feet high is not uncommon. If left open, these large doors will permit a much greater entrance of warm air or outflow of refrigerated air than the small doors and may prevent holding temperatures low in the room. Further work will be done to determine the heat loss through these large doors.

EQUIPMENT AND METHODS

To eliminate the entrance of warm air to the cold storage rooms, swinging rubber doors, sliding doors, or canvas curtains have been used as secondary doors to close off the opening when the main (insulated) doors are open. The use of such doors is costly at best. First cost of a secondary door in many cases is high, and continual maintenance is required. In some buildings an entire new door has been required to replace the one damaged beyond repair by a lift truck.

The use of a steady directional stream of air across the doorway effectively seals off the opening and gives a clear and unobstructed entrance and exit (fig. 1).

Figure 1.--Forklift truck operator has clear view ahead while passing through air door with a load of four pallet boxes.

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To distribute the air evenly across the doorway at a constant velocity it is necessary to have a louvered duct down one side of the door opening and an open duct down the other side (figs. 2 and 3). An enclosed duct across the top of the door houses the motor and fan which circulate the air through the ducts. The air blows from the louvered duct across the doorway to the open duct. The same amount of air must enter the open duct as it leaves the louvered duct. Air does not enter or leave the airstream when the louvers are properly adjusted and the air is distributed evenly across the face of the louvers (fig. 4).

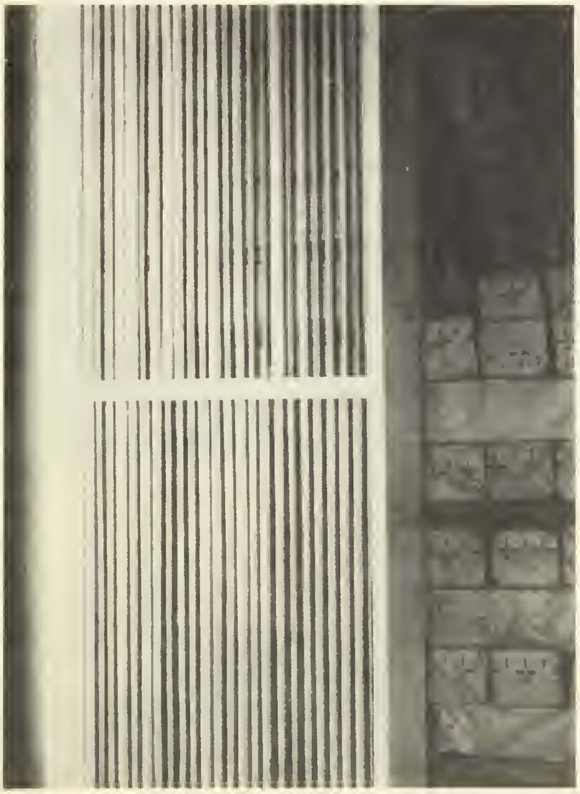

Figure 2.--Air passes through louvers and is distributed evenly across doorway.

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Figure 3.--After air crosses doorway it enters the open duct. Screen has been removed to show inside construction of turns and guide channels.

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Figure 4.--Testing air flow across an air door with a smoker to determine the air currents.

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Louvers

The louvers are made in two sections, an upper section and a lower section (fig. 2). The vertical vanes of each louver are pinned to a horizontal 1- by 4-inch board at each end by a single nail. This allows each vane to be adjusted individually.

The reason for this adjustment is to direct the air across the door so that it resists the tendency of air to enter or leave the storage. When a storage door is left open, warm air enters at the top half of the door opening and cold air rushes out through the lower half of the door opening (fig. 5).

Since the vanes are adjustable, they can be turned at an angle that will allow the airstream to resist the inflowing and outflowing air. At times, the airstream across the doorway will travel in a curved path because of the pressure difference between the air inside the storage and the air outside the storage. This curvature does not impair the operation of the air door. The adjustment of the vanes can be aided by use of a simple bee smoke pot (fig. 4), or by the use of streamers tied to a movable wire (fig. 6).

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Figure 5.--When fan of air door is not operating, warm air enters storage through top half of open door and cold air flows out of the lower half, as indicated by streamers on wire.

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Figure 6.--Testing airflow pattern with paper streamers tied to a vertical wire showing the movement of the air within the doorway.

Air Movement

There are several ways in which the air can move across a door opening and still act as a curtain. If the air moves from top to bottom of the door, a pit and ducts may be necessary to conduct the airstream back to the fans again.

Some types of doors use a high velocity airstream moving from the top of the door to the floor. This is directed into or out of the storage as it strikes the floor, and is accompanied by some loss or mixture of air.

The air in the air door of this discussion moves horizontally across the door, making it easy to confine the air to the intended path. This also eliminates the expense of a pit and additional ducts. However, in some storages a vertical airstream with a pit may be more desirable.

With an 8-foot-wide door, the air velocity should not be less than 200 feet per minute to effectively seal the door opening. If the door is situated where high velocity gusts of wind can strike it, higher velocities may be required for the airstream across the door.

Although the air door tested in this study was located inside the storage room, the air door would be equally effective if located on the warm side of the door opening.

Motor and Fan

The selection of a motor and fan is not difficult. The velocity of the airstream required (feet per minute) times the area of the duct opening on one side of the air door (in square feet) gives the volume of air required in cubic feet per minute. Example:

If the air door is 11 feet high and 4 feet deep, the opening area would be 11 x 4, or 44 square feet. If the air velocity required is 200 feet per minute, then 200 x 44 = 8,800 cubic feet per minute, the volume of air required. The volume of air to be delivered by the fan can be assumed to be free delivery. Tests have shown that static pressure is less than 1/16-inch of water. However, the static pressure will vary with each installation and volume of air delivered by the fan.

Guide Channels

The guide channels are made of 3/8-inch exterior plywood and are required to distribute or divide the air evenly over the entire face of the delivery and return air openings. If it were not for the guides or splitters, the air would tend to short circuit at the top of the door and would not give full coverage to the door opening (fig. 7).

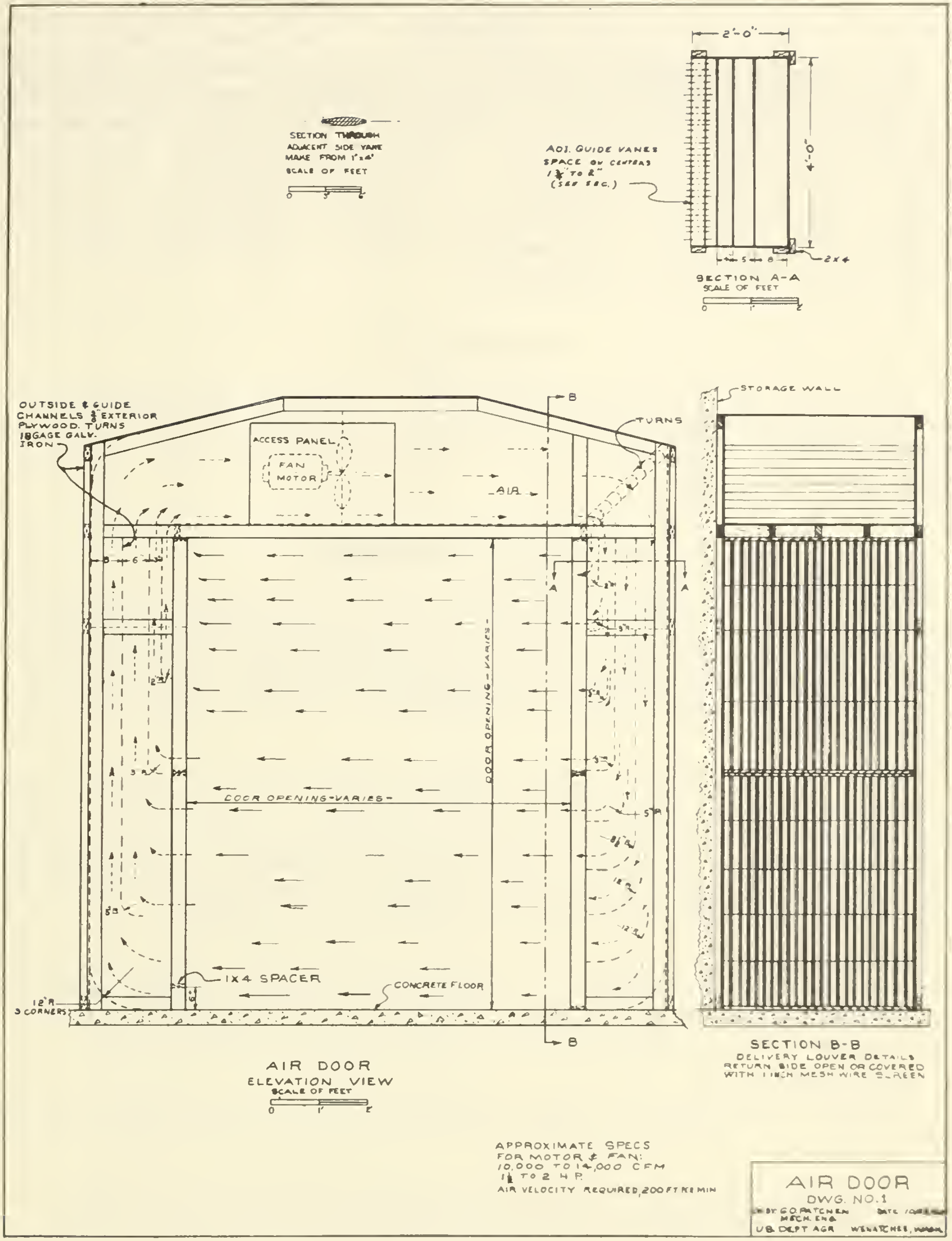

Figure 7.--Details of air door.

Metal Turns

Metal turns are required to change the direction of the air and help keep the air in straight flow lines. The straighter the air path, without whirls or excessive turbulence, the more effective the air door. The turns are made of 18-gage galvanized iron. If lighter gage metal is used, the turns tend to flutter in the high velocity airstream. Turns help to distribute the air evenly across the face of the opening, and the air velocity is more uniform than if no turns are used. The turns cause the air to travel in a more nearly horizontal direction than it is possible to obtain without turns, and also reduce the friction loss in the system.

ESTIMATED COST

Air doors of this type cost about $500. If suitable spare motors or fans are available around the storage house, the cost can be materially reduced. Two carpenters should be able to erect an air door of this type in 3 days' (6 man-days) working time.

CONCLUSIONS AND RECOMMENDATIONS

The air volume and velocities for the air door described in this report are for minimum requirements. Should the door be exposed to strong winds or gusts of wind, it will be necessary to increase the velocity of air across the face of the door to maintain a continuous air curtain. The higher the velocity of the air making up the air curtain, the more resistance it will have to air currents.

The air should flow in straight, parallel paths for best operation. This can be accomplished by keeping the inside surfaces of the guide channels smooth and avoiding as much as possible any internal bracing or wide boards that would offer a resistance to the air or disturb its flow. Where it is necessary to have crosspieces in the airstream, the leading and trailing edges of the cross-pieces should be leveled to lessen their effect on the airflow.

The full capacity of the fan is not required at times, especially on days when there is little air movement. At such times, there is some advantage to having a variable-speed fan, because the greater the air output of fan, the more horsepower will be required and the more expensive the operation.

A good means of determining the airflow pattern of an air door is by the use of smoke. An ordinary bee smoker can be used very satisfactorily for such tests (fig. 4).

Even distribution of the air on the delivery and suction, or return, sides of the air door should be maintained by adjusting the width of the guide openings. This will prevent excessive blow-by, or loss of air, on the suction side.

Particular attention should be paid to the turns which are installed on the ends of the guide channels. These turns should extend to the inside face of the louvers as shown in figure 7. This will help direct the air horizontally and prevent it from blowing toward the floor. Should the air blow toward the floor on the delivery side, the effectiveness of the air door is materially decreased.

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